Bull. Mus. natn. Hist. nat., Paris, 4e sér., 7, 1985,
section A, n° 1 : 219-233.

Resurrection of *Galeus atlanticus* (Vaillant, 1888), as a valid species from the NE-Atlantic Ocean and the Mediterranean Sea

par R. Muñoz-Chápuli and A. Perez Ortega

Abstract. — *Galeus atlanticus* (Vaillant, 1888) is resurrected as a valid species based on 26 specimens from the Alboran Sea. Comparison was made with 50 specimens of the other three species of the genus *Galeus* from the north eastern Atlantic, *G. melastomus, G. murinus* and *G. polli*. External morphological characters, different modes of reproduction and chondrocranial measurements allow separation of all these species.

Résumé. — Validation de *Galeus atlanticus* (Vaillant, 1888) fondée sur 26 exemplaires de la mer d'Alboran et comparaison avec 50 exemplaires des trois autres espèces du genre *Galeus* de l'Atlantique nord-oriental, *G. melastomus, G. murinus* et *G. polli*. Des caractères morphologiques externes, les différents modes de la reproduction, et les mesures du chondrocrâne permettent la séparation de ces espèces.

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Introduction

Several hundred trawled specimens of the genus *Galeus* were observed during the summer of 1983 in the fishmarket of Málaga (Spain). They were fished in the bay of Málaga (fig. 1) between 400 and 600 m. depth. One third of these specimens differed from

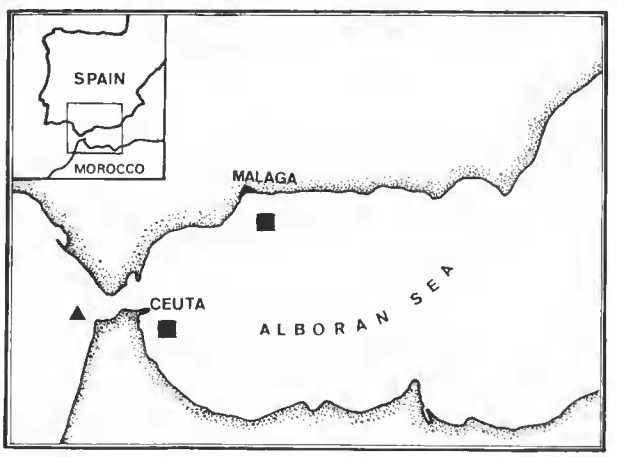

Fig. 1. — Capture localities of *G. atlanticus*. Squares : UMDZ specimens. Triangle : locus typicus.

G. melastomus, the common species in the Mediterranean Sea and NE-Atlantic Ocean, and were very similar to three specimens caught several months before near Ceuta (Spain ; fig. 1) between 400 and 500 m. depth. Their differences from *G. melastomus* were : size at maturity, colour pattern, head shape, clasper structure, number of vertebral centra and the length of the anal fin base.

A comparison was made between the unique recently collected specimen and several examples of *G. murinus* (Collet, 1904) and *G. polli* Cadenat, 1959, the other species of the genus *Galeus* in the Eastern Atlantic. None of these shared the above mentioned characters with the collected specimens.

However, the description of *Pristiurus atlanticus* Vaillant, 1888, an old taxon usually synonymized with *G. melastomus*, coincides with the sharks under study. *Pristiurus atlanticus* has been considered as an invalid species at least since Garman (1913). The type locality (Cape Espartel, Morocco ; fig. 1) is also in agreement with our unidentified specimens.

A radiograph of the holotype, deposited in the Muséum national d'Histoire naturelle at Paris (MNHN 84-387), obtained thanks to the courtesy of Dr. M. L. Bauchot, confirmed this hypothesis. The species taxon *atlanticus* should be considered as valid, with correct generic assignment, as *Galeus atlanticus* (Vaillant, 1888).

A complete re-description of this species is herein presented, together with a detailed comparison with *G. melastomus* in external morphology, chondrocranium, pectoral skeleton, vertebral counts, etc., and with *G. murinus* and *G. polli* in external morphology. Several aspects of its biology are also included.

Finally, a synopsis of the genus *Galeus* is given, commenting on similarities and differences between *G. atlanticus* and the other species.

Material examined

The following specimens were examined in this study (M = male, F = female, total length in millimeters) :

G. atlanticus : UMDZ 83071302, F, 426 ; UMDZ 83073013, M, 316 ; UMDZ 83073014, F, 413 ; UMDZ 83073015, M, 402 ; UMDZ 83073016, F, 434 ; UMDZ 83073017, M, 423 ; UMDZ 83073018, F, 386 ; UMDZ 83073019, M, 346 ; UMDZ 83073020, M, 384 ; UMDZ 83073021, F, 348 ; UMDZ 83073023, F, 356 ; UMDZ 83073024, M, 308 ; UMDZ 83073025, M, 415 ; UMDZ 83073026, M, 342 ; UMDZ 83073027, M, 341 ; UMDZ 83073028, M, 402 ; UMDZ 83073029, M, 398 ; UMDZ 83080303, F, 417 ; UMDZ 83080305, F, 436 ; UMDZ 83080306, F, 396 ; UMDZ 83080307, F, 427 ; UMDZ 83080308, F, 398 ; UMDZ 83080309, F, 442 ; all caught in the bay of Málaga (Spain). — UMDZ 83042201, M, 417 ; UMDZ 83042202, F, 415 ; UMDZ 83052601, F, 408 ; caught off Ceuta (Spain). — All 26 specimens deposited in the Department of Zoology, University of Málaga (UMDZ).

G. melastomus : UMDZ 83052602, F, 455 ; UMDZ 83070702, M, 564 ; UMDZ 83071401, F, 600 ; UMDZ 83071402, M, 533 ; UMDZ 83071403, M, 409 ; UMDZ 83073002, M, 367 ; UMDZ 83073003, F, 418 ; UMDZ 83073004, F, 353 ; UMDZ 83073005, M, 460 ; UMDZ 83073006, F, 373 ; UMDZ 83073007, M, 367 ; UMDZ 83073008, M, 372 ; UMDZ 83073009, M, 431 ; UMDZ 83073010, F, 430 ; UMDZ 83073011, M, 512 ; UMDZ 83080304, M, 500 ; all caught in the bay of Málaga. — UMDZ 84043001, 3 juvenile F and 1 juvenile M, 358-430, caught in the FRV " Walther Hervig " Stat. 37/84 : Rockall Trough (56°37.6′ N, 14°06.2′ W), 342-343 m depth. UMDZ 84043002, 8 adult F, and 1 adult M, 617-690, caught in the FRV " Walther Hervig " Stat. 32/84 : Rockall Trough (56°21′ N, 14°20′ W), 584-600 m. depth. — These North Atlantic specimens were donated by the Institut für Seefischerei Hamburg (ISH) (F. R. Germany) to the UMDZ.

G. murinus : ISH 41/65, 2 F and 3 adult M, 479-545, caught off W-Iceland (64°07′ N, 27°16′ W), 800 m depth. — 2 specimens deposited in the ISH and 3 donated by this institute to UMDZ.

G. polli : ISH 391/64, F, 385, 15°51′ N, 16°56′ W, 140-250 m ; ISH 1074/64, M, 301, 7°12′ N, 12°46′ W, 360 m ; ISH 1116/64, M, 308, 5°38′ N, 10°25′ W, 400 m ; ISH 1248/64, F, 255, 4°42′ N, 2°47′ W, 400 m ; ISH 1368/64, F, 279, 7°12′ N, 12°46′ W, 360 m ; ISH 1592/64, M, 302, 7°12′ N, 12°46′ W, 360 m ; ISH 194/67, F, 236, 11°04′ S, 13°30′ E, 440 m ; ISH 227/77, M, 357, Cape Blanc, about 21° N ; ISH 229/77, F, 275, 21°30′ N, 17°08′ W ; ISH 231/77, 2 specimens, M, 163 and F, 154, Cape Blanc, about 21° N ; ISH 233/77, 2 specimens, F, 322 and 368, 21°30′ N, 17°08′ W ; ISH 238/77, F, 308, 21°30′ N, 17°08′ W. — All specimens deposited in ISH.

Two uncatalogued specimens (M, 353 ; F, 367) out of the J. CADENAT collection, caught off Senegal in 1959. Specimens deposited in the Centre ORSTOM in Dakar (Sénégal).

REDESCRIPTION OF *Galeus atlanticus*

Body moderately slender, caudal fin axis horizontal. Trunk (snout tip to anus) about 2/5 of total length. Head short, less than 1/5 of TL, broad at base, slightly pointed towards snout, somewhat variable in shape. Nasal apertures large, oblique, their greatest length more than 1/3 of preoral snout length. Internasal distance short, less than nostril length. Mouth large, wider than distance of snout tip to mouth. Superior labial groove clearly shorter than the inferior. Eye moderately large, its horizontal length 1/4 of distance from snout tip to pectoral origin. Gill openings short, the first more advanced than remaining, 1/2-2/5 of the eye-length. First dorsal origin in front of end of pelvic base. Second dorsal fin distinctly larger than the first, with its origin posterior to maximum height of anal fin. Free basal margin of both dorsal fins shorter than height of these fins. Distance between second dorsal fin base and origin of superior caudal lobe less than second dorsal base. Anal fin low and very long, its base equal to or longer than distance between pectoral origin and anterior tip of nasal openings. Anal fin shorter in adult males

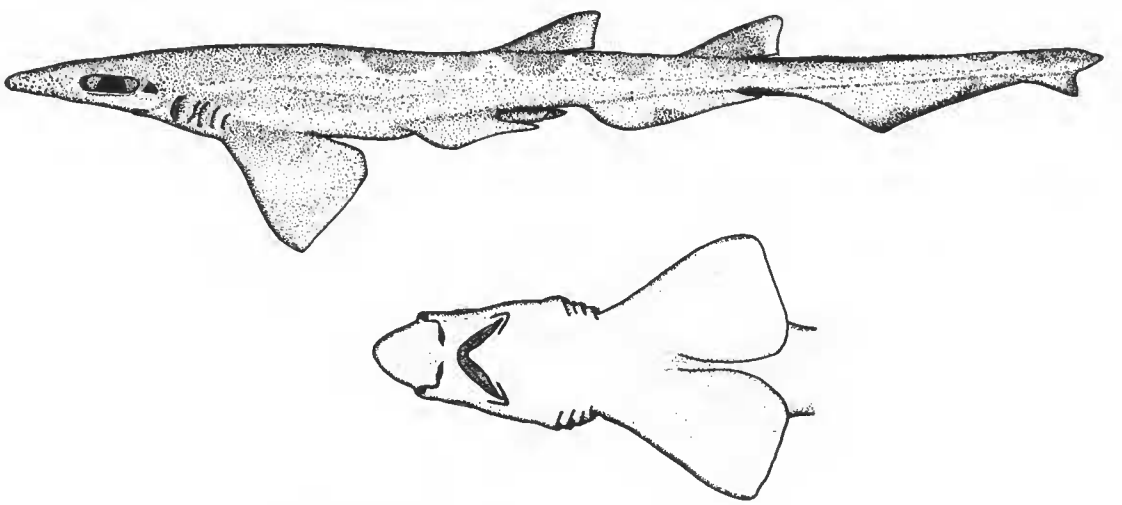

FIG. 2. — *Galeus atlanticus* adult male (415 mm, UMDZ 83073025).

(2-3 % of TL). Pectoral fins broadly triangular, the outer corner rounded, the anterior convex and posterior margins almost straight ; anterior margin slightly shorter than the distance between snout and first gill opening. Pelvic fins narrow and elongate. Caudal fin long and narrow, slightly bent downwards, the distal lobe well marked.

Dorsal colour grey, uniform on the head and anterior part of trunk, but with 8-9 saddle-like dark blotches along the posterior part of trunk and caudal region. Additional smaller saddle blotches alternating with the larger ones. Narrow light borders delimit the saddle blotches and separate them from the sides, which are greyish. Ventral region whitish. Dorsal fins dark, the posterior margin semitransparent. Inferior margin of caudal black. A dark stripe along base of pectoral fins. Mouth cavity and gill openings black. Nasal openings white.

One specimen (UMDZ 83042201) showed some particular features. Its snout is shorter and more pointed than the remaining specimens. Its body is uniformly brown, darker on the back and flanks. However, the authors provisionally consider it as *G. atlanticus*.

Comparison with the other species of *Galeus*

Morphometrics

Table 1 gives the measurements of 8 specimens of *G. atlanticus*, of 20 *G. melastomus*, 5 *G. murinus* and 14 *G. polli*, expressed as percentage of TL. These were made according to the methods described by Bigelow and Schroeder (1948).

The differences between *G. atlanticus* and *G. melastomus* are obvious, in that *G. atlanticus* has a shorter head and snout, longer and widely separated nasal openings, shorter superior labial groove, more anterior first dorsal fin, more separated dorsal fins, longer and lower anal fin, and a deeper caudal peduncle than *G. melastomus*.

G. murinus is morphometrically very different from the remaining species. Its tip of snout to anus distance is greater, head wider, inferior labial groove larger, origin of first dorsal fin more posterior, second dorsal fin nearer to origin of superior caudal fin lobe. Furthermore, its pectoral bases are more widely separated, and its anal fin base shorter than in remaining species.

G. polli is distinct in the long free basal margin of both its dorsal fins, which is longer than the height of these fins. In the remaining species, the height of the dorsal fins is larger than the free basal margin.

The samples of *G. melastomus* from the Rockall Trough and bay of Málaga were measured and processed separately. Only two characters showed significant differences in the two samples : the minimum internasal distance and the free basal margin of second dorsal fin ; both were smaller in the Rockall specimens.

Table 2 shows the t-Student test for the differences in the arithmetic means of *G. atlanticus* and the remaining species.

TABLE 1. — Morphometric measurements in percentage of TL.

SPECIES:	G. atlanticus				G. melastomus				G. murinus				G. polli			
TL - Range:	346-442 mm.				358-690 mm.				479-545 mm.				154-385 mm.			
Tip of snout to:	n	$\bar{x}$	s	Σx^2	n	$\bar{x}$	s	Σx^2	n	$\bar{x}$	s	Σx^2	n	$\bar{x}$	s	Σx^2
- Upper caudal origin	8	72.74	0.51	42324.85	19	71.58	1.32	97375.96	5	72.63	0.11	26372.73	14	71.07	1.80	70755.39
- Anterior end of anus	8	40.77	1.59	13317.74	20	42.62	1.29	36354.19	5	46.52	1.29	10827.18	14	41.75	0.92	23860.09
- 1st gill slit	8	14.68	0.72	1726.50	20	15.75	0.75	4972.97	5	15.79	0.65	1248.97	14	16.32	0.76	3736.57
- 5th gill slit	8	18.66	0.46	2786.70	20	20.14	0.76	8126.68	5	20.76	0.86	2157.01	14	21.24	0.94	6392.48
- Anterior nasal opening	8	3.64	0.35	106.99	20	4.44	0.32	396.36	5	4.26	0.36	91.42	14	3.83	0.26	205.97
- Mouth	8	7.16	0.50	412.16	20	7.85	0.53	1177.05	5	7.66	0.45	294.49	14	7.89	0.58	875.80
- Eye	8	6.61	0.42	350.92	20	7.29	0.41	1065.66	5	7.60	0.64	290.43	14	7.51	0.55	794.39
- Pectoral origin	8	18.31	0.60	2683.09	20	19.65	0.70	7727.89	5	20.05	0.72	2011.71	14	20.83	0.97	6085.35
- D_1 origin	7	44.51	0.76	13872.33	19	45.90	1.32	40061.67	5	47.76	0.46	11404.01	14	44.46	1.80	27721.23
Head width	8	10.50	0.73	885.73	15	10.32	0.86	1609.32	5	12.18	0.81	744.62	14	10.82	1.11	1653.38
Orbit length	8	4.44	0.26	158.06	20	3.99	0.16	319.22	5	3.97	0.27	79.01	14	4.32	0.46	263.97
Length of nasal openings	8	2.79	0.21	62.58	19	2.42	0.29	113.10	5	2.51	0.29	31.73	14	2.90	0.20	118.53
Minimum internasal distance	8	2.30	0.15	42.30	19	2.70	0.25	139.38	5	2.54	0.17	32.37	14	2.48	0.17	86.76
Maximum internasal distance	8	6.63	0.35	352.66	19	6.47	0.38	797.50	5	7.08	0.47	251.52	14	7.09	0.54	707.52
Mouth width	8	7.46	0.57	446.90	20	7.72	0.50	1197.70	5	8.33	0.68	349.14	14	7.55	0.62	801.93
Mouth height	8	3.29	0.56	88.78	19	2.85	0.40	156.93	5	2.54	0.47	33.12	14	3.06	0.47	134.18
Length inferior labial groove	8	1.62	0.12	21.10	19	1.72	0.18	56.77	5	2.33	0.16	27.29	14	1.89	0.19	50.33
Length superior labial groove	8	1.30	0.18	13.72	19	1.70	0.17	55.30	5	1.70	0.15	14.54	14	1.47	0.13	30.51
Height 1st gill slit	8	2.03	0.26	33.51	19	2.20	0.22	92.62	5	1.57	0.35	12.77	14	1.64	0.23	38.26
Height 3rd gill slit	8	1.96	0.31	31.26	19	2.08	0.26	83.36	5	1.78	0.17	16.00	14	1.60	0.39	37.93
Height 5th gill slit	8	1.40	0.21	15.95	19	1.52	0.12	44.38	5	1.24	0.20	7.90	14	1.34	0.22	25.74
1st gill-5th gill distance	8	4.69	0.48	177.48	19	4.82	0.89	456.24	5	4.83	0.40	117.28	14	5.08	0.44	363.31
O_1 base length	8	4.90	0.62	194.97	20	5.29	0.44	562.70	5	5.27	0.31	139.14	14	5.62	0.47	445.34
O_1 height	8	3.16	0.33	80.53	19	3.15	0.46	192.79	5	3.33	0.39	56.04	14	2.59	0.34	95.57
D_1 free basal margin	8	3.03	0.24	73.99	19	2.87	0.25	158.17	5	2.43	0.38	30.06	14	3.34	0.32	157.28
D_2 base length	8	5.81	0.50	272.17	20	5.64	0.49	641.28	5	6.21	0.41	193.37	14	5.58	0.37	436.88
O_2 height	8	3.38	0.27	91.76	19	3.57	0.43	244.99	5	3.99	0.37	80.30	14	2.71	0.30	104.08
O_2free basal margin	8	3.09	0.32	77.10	19	2.71	0.27	140.54	5	2.50	0.39	31.75	14	3.16	0.30	141.14
Interdorsal distance	8	13.46	0.86	1454.54	19	12.19	0.63	2829.09	5	10.49	0.75	552.67	14	11.51	0.94	1867.47
O_2 base-upper caudal origin distance	8	4.91	0.67	196.15	19	4.00	0.48	308.84	5	3.02	0.50	46.47	14	5.30	0.78	400.55
Interpectoral distance	8	4.15	0.57	140.08	15	3.20	0.63	158.76	5	7.28	1.30	271.78	14	3.69	0.64	195.95
Pectoral base length	8	8.09	0.33	524.34	20	8.01	0.44	1286.42	5	6.55	0.81	216.86	14	7.00	0.56	690.85
Pectoral anterior margin length	8	13.78	0.94	1524.14	19	12.96	0.75	3199.37	5	11.40	0.60	650.99	14	12.40	1.10	2167.24
Pectoral posterior margin length	8	10.39	0.70	866.82	19	10.87	0.60	2250.76	5	9.53	0.40	455.14	14	8.75	1.36	1096.77
Pectoral inner margin length	8	8.30	1.02	557.95	19	7.37	0.54	1036.83	5	6.41	0.65	206.87	14	7.00	1.02	699.23
Pelvic length	8	11.83	1.01	1126.30	20	11.86	0.64	2819.13	5	11.63	1.00	680.08	14	11.55	1.25	1888.35
Anal fin base length	8	16.89	1.50	2297.83	20	15.44	1.13	4794.49	5	11.27	0.45	635.43	14	15.34	1.15	3313.58
Anal fin height	8	3.91	0.40	123.43	20	4.86	0.95	488.86	4	5.24	0.11	109.86	14	3.82	0.64	209.02
Anal fin free basal margin length	8	1.89	0.31	29.22	19	1.72	0.22	57.25	5	1.54	0.19	12.00	13	1.80	0.18	42.43
Anal fin base-lower caudal origin	8	2.67	0.74	60.81	19	2.29	0.25	100.73	5	1.52	0.23	11.70	14	2.91	0.63	123.66
Upper caudal lobe length	8	27.80	0.84	6188.22	20	28.41	1.29	16172.43	5	27.37	0.11	3746.73	14	28.89	1.83	11724.21
Lower caudal lobe length	8	9.01	0.64	651.57	20	9.23	0.79	1716.37	5	9.79	0.57	480.14	14	10.02	0.76	1414.18
Caudal peduncle height	8	4.88	0.36	191.41	19	4.16	0.33	330.92	5	4.04	0.13	81.84	14	3.81	0.37	204.67

Specimens measured : *G. atlanticus* : UMDZ 83042201, UMDZ 83042202, UMDZ 83052601, UMDZ 83073017, UMDZ 83073019. UMDZ 83073021, UMDZ 83080309, UMDZ 83071301 ; *G. melastomus* : UMDZ 83071401, UMDZ 83071402, UMDZ 83071403, UMDZ 83073008, UMDZ 83073009, UMDZ 83073010, UMDZ 83073011, ISH 32/84 (9 specimens), ISH 37/84 (4 spec.) ; *G. murinus* : All the specimens quoted in " material examined " ; *G. polli* : All the specimens quoted in " material examined ", except those of CADENAT's collections.

TABLE 2. — Comparison of parametric means between *G. atlanticus* and *G. melastomus, G. murinus* and *G. polli.*

Parameter:	G. melastomus		G. murinus		G. polli	
	t	d.f.	t	d.f.	t	d.f.
Tip of snout to:						
- Upper caudal origin	2.32	25			2.45	20
- Anterior tip of anus	3.08	26	6.26	11		
- 1st gill slit	3.32	26	2.58	11	4.73	20
- 5th gill slit	4.96	26	5.26	11	6.94	20
-Anterior nasal opening	5.60	26	2.83	11		
- Mouth	3.05	26			2.84	20
- Eye	3.79	26	3.10	11	3.82	20
- Pectoral origin	4.59	26	4.25	11	6.35	20
- O_1 origin	2.53	24	7.77	10		
Head width			3.56	11		
Orbit length	5.35	26	2.87	11		
Length of nasal openings	3.14	25				
Minimum internasal distance	4.06	25	2.45	11	2.38	20
Mouth width			2.28	11		
Mouth height			2.30	11		
Length inferior labial groove			8.38	11	3.46	20
Length superior labial groove	5.28	25	3.82	11	2.44	20
Height 1st gill slit			2.49	11	3.48	20
O_1 base length					2.93	20
O_1 height					3.65	20
O_1 free basal margin			3.21	11	4.98	20
O_2 height			3.15	11	4.98	20
O_2 free basal margin	3.04	25	2.73	11		
Interdorsal distance	4.11	25	5.85	11	4.60	20
O_2base-upper caudal origin distance	3.82	25	5.00	11		
Interpectoral distance	3.40	21	5.48	11		
Pectoral base length			4.40	11	4.79	20
Pectoral anterior margin length	2.31	25	4.65	11	2.84	20
Pectoral posterior margin length			2.30	11	3.03	20
Pectoral inner margin length	2.96	25	3.40	11	2.74	20
Anal fin base length	2.68	26	7.50	11	2.59	20
Anal fin height	2.63	26	5.96	10		
Anal fin base-lower caudal origin			3.10	11		
Lower caudal lobe length					3.02	22
Caudal peduncle height	4.85	25	4.62	11	6.28	20

All the t-values are significant to a level of confidence superior to 95 %. t-values more than 2.80 for *G. melastomus*, 3.11 for *G. murinus* and 2.84 for *G. polli* are significant to a level of confidence superior to 99 %.

Chondrocranium

The chondrocrania of 11 specimens of *G. atlanticus* and of 13 *G. melastomus* were cleaned in boiling water. Twelve chondrocranial measurements were taken of both species (fig. 3) ; these were expressed as percentages of total length of chondrocranium (TLC), (table 3). Out of these 12 measurements, 7 show significant differences between the two species after the t-Student test (table 4).

TABLE. 3. — Chondrocranial measurements of selected specimens of *G. atlanticus* and *G. melastomus* expressed as percentage of TLC.

Species:	G. atlanticus				G. melastomus			
Total length of chondrocrania (TLC):	44.9-61.5 mm.				48.8-73.9 mm.			
	n	$\bar{X}$	s	Σx^2	n	$\bar{X}$	s	Σx^2
Posterior tip-precerebral fossa	11	43.73	1.97	21072.67	13	42.00	0.92	22945.58
Length precerebral fossa	11	26.07	1.09	7409.01	13	24.08	1.04	7551.49
Width nasal capsulae	11	53.69	1.69	31735.08	13	52.80	1.69	36271.79
Postorbital width	11	58.67	2.32	37916.52	13	57.32	1.05	39434.43
Width precerebral fossa	11	11.35	1.03	1428.07	13	13.64	0.81	2425.64
Interorbital width	11	12.46	0.59	1711.24	13	14.90	0.54	2889.57
Distance between orbital processes	11	41.22	1.59	18716.96	13	35.94	1.65	16826.78
Width suborbital shelves	11	44.77	1.97	22083.91	12	43.72	1.44	22960.20
Inferior minimum width	11	28.45	1.33	8921.24	13	28.16	0.92	10317.23
Posterior basal width	11	41.90	1.81	19346.87	13	39.06	1.31	19850.69
Maximum height	11	22.11	0.90	5387.27	13	20.57	0.53	5504.01

TABLE 4. — Comparison of chondrocranial means of *G. atlanticus* (A) and *G. melastomus* (B).

	A	B	d.f.	t
Posterior tip-precerebral fossa	43.73	42.00	22	2.70 *
Length precerebral fossa	26.07	24.08	22	4.37
Width precerebral fossa	11.35	13.64	22	5.83
Interorbital width	12.46	14.90	22	10.12
Distance between processes	41.22	35.94	22	7.60
Posterior basal width	41.90	39.06	22	4.26
Maximum height	22.11	20.57	22	4.97

* Significant to a level of confidence superior to 95 %. Remaining means are differents to a level of confidence superior to 99 %.

The chondrocranium of *G. atlanticus* has a longer and narrower cerebral cavity and a longer precerebral fossa than *G. melastomus*. The distance between antorbital and postorbital processes is larger in *G. atlanticus*, as would be expected from its larger eye. The posterior base of the chondrocranium is broader, and its maximum height is larger in *G. atlanticus* than in *G. melastomus*.

The relative increase of the chondrocranial measurements with growth was also studied. Several trends were observed in the sample of *G. melastomus* (table 5). These were not detected in *G. atlanticus*, probably because of the small size range of the specimens studied (almost exclusively adults). Allometry in growth can be expected to be greater in the range of length of immature individuals than the range of adults. In the chondrocranium of *G. melastomus* there is a relative increase of the distance between orbital processes, in

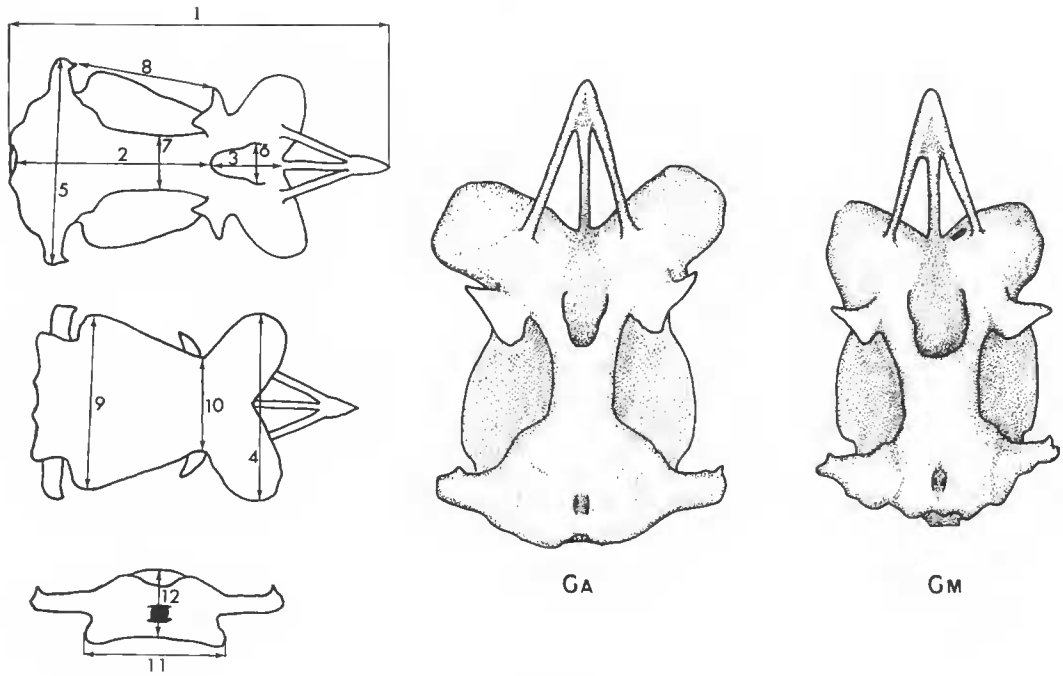

FIG. 3. — Chondrocrania of *Galeus atlanticus* (UMDZ 83073020, 384 mm TL, 53.0 mm TLC) and *G. melastomus* (UMDZ 83073004, 353 mm TL, 48.8 mm TLC). At left hand, parameters measured in chondrocrania : 1 = TLC, 2 = posterior tip-precerebral fossa, 3 = length precerebral fossa, 4 = width nasal capsulae, 5 = postorbital width, 6 = width precerebral fossa, 7 = interorbital width, 8 = distance between antorbital and postorbital processes, 9 = width suborbital shelves, 10 = inferior minimum width, 11 = basal posterior width, 12 = maximum height.

TABLE 5. — Trends of the relative growth in the chondrocranium of *G. melastomus* (X = total length of chondrocranium ; Y = relative length of parameter in percentage of TLC).

Total length chondrocranium / length precerebral fossa :	$Y = 9.10\ X^{0.24}$	(r = 0.69)
Total length chondrocranium / orbital processes distance :	$Y = 14.75\ X^{0.22}$	(r = 0.62)
Total length chondrocranium / suborbital shelves width :	$Y = 19.99\ X^{0.19}$	(r = 0.66)
Total length chondrocranium / posterior basal width :	$Y = 17.75\ X^{0.19}$	(r = 0.73)

posterior basal width, suborbital shelf width and precerebral fossa length with growth. It is impossible to compare these results with those of other authors, since they have not yet been used for taxonomic evaluations, although proposed by HUBBS and ISHIYAMA (1968) for rajids. The high yield of interspecific differences in the chondrocranial measurements shows that this metodology should be useful in future taxonomic work.

Pectoral skeleton

The number of radial cartilages in the pectoral skeletons of 9 *G. atlanticus* and 12 *G. melastomus* are shown in table 6. *G. atlanticus* is easily separable from *G. melastomus*

by its lower number of radials. There is also a difference in number of radial cartilages fused and articulating to the mesopterygium, namely 2 in *G. atlanticus* and 3 in *G. melastomus* (fig. 4).

TABLE 6. — Comparison of number of pectoral radials.

Number of radial cartilages :	17	18	19	20	21
G. atlanticus (N) :	5	4			
G. melastomus (N) :			2	7	3

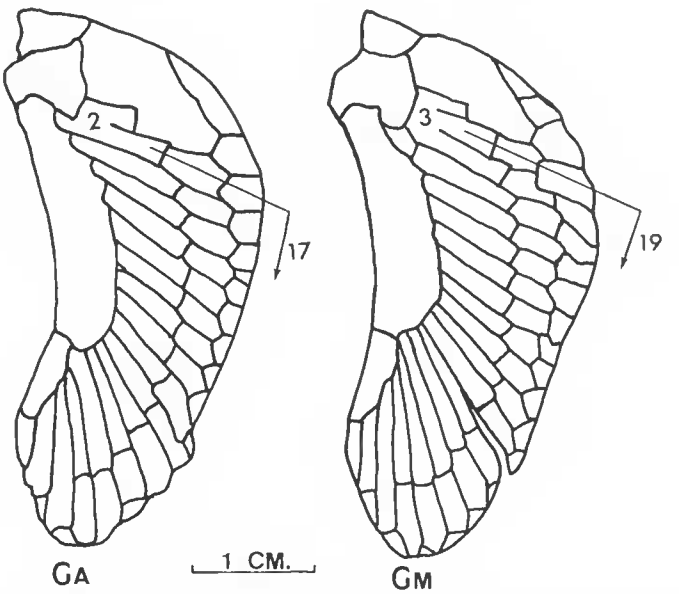

FIG. 4. — Pectoral fin skeletons of *G. atlanticus* and *G. melastomus*. 2, 3 = elements of the fused radial cartilages articulating to the mesopterygium.

Number of vertebral centra

Vertebral centra were counted from radiographs or dissected specimens. The results are shown in table 7. *G. atlanticus, G. murinus* and *G. polli* have similar numbers of monospondylous centra. Precaudal centra numbers, however, allow separation of *G. murinus* (66-67), *G. atlanticus* (70-73) and *G. melastomus* (78-81).

Teeth

The presence of two or more lateral cusps at each side of a tooth, was a main feature used by VAILLANT (1888) in his description of *G. atlanticus*. However, the shape of teeth in the four species examined was very variable. Double or triple lateral cusps were more frequent in both *G. polli* and *G. atlanticus* than in *G. melastomus* or *G. murinus*. In all

four species these lateral cusps were more developed in lateral and lower jaw teeth than in symphyseal and upper jaw teeth.

The teeth of *G. murinus* have wider striations than those of *G. melastomus*, but both are similar in shape. The teeth of *G. atlanticus* and *G. polli* are indistinguishable.

Figure 5 shows the shape of upper and lower jaw teeth in the four species of *Galeus*.

TABLE 7. — Comparison of number of vertebral centra.

No. Vertebral centra:	32	33	34	35	36	37	38	39	66	67	70	71	72	73	78	79	80	81
G. atlanticus (N):		8	4								1	1	9	1				
G. melastomus (N):						1	9	3							1	1	10	1
G. murinus (N):		1	2	1	1				2	3								
G. polli* (N):	2	16	33	18														

*(after Cadenat and Blache, 1981)

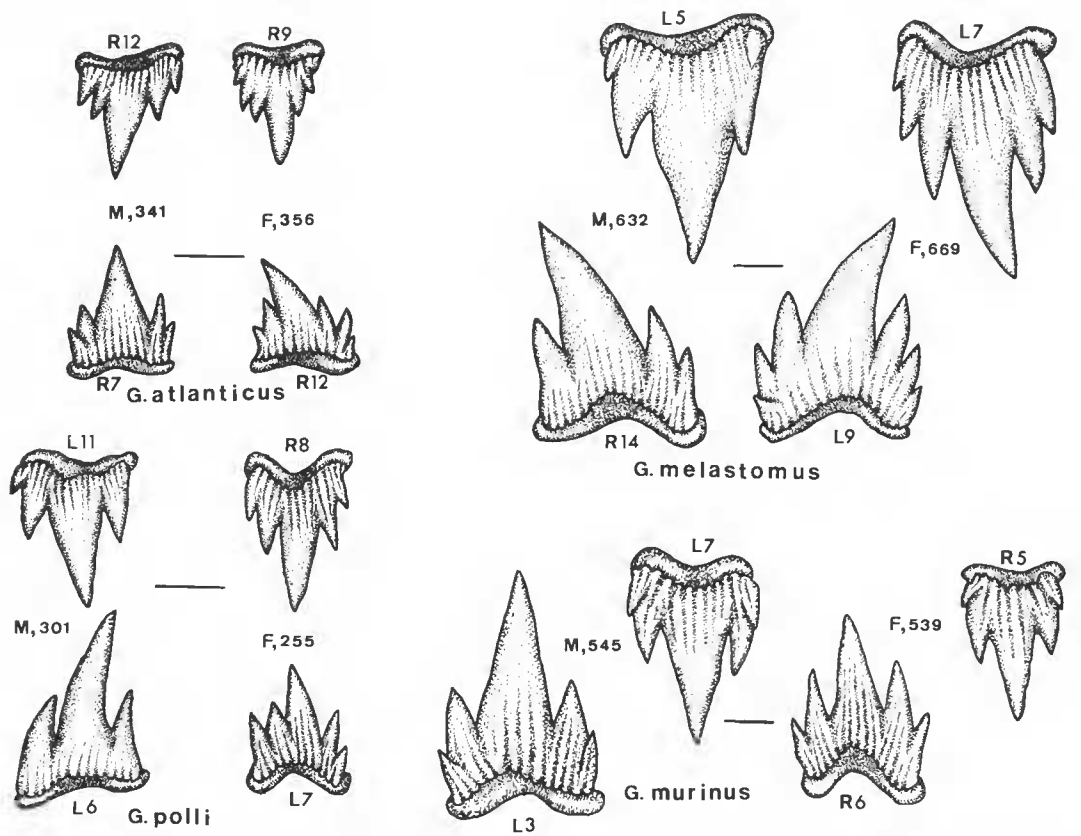

FIG. 5. — Upper and lower teeth of *Galeus atlanticus, G. melastomus, G. murinus*, and *G. polli*. M = male, F = female. R = right, L = left. The row which teeth belong is given by the number. Total length in mm. Scale = 1 mm.

Dermal denticles

Dermal denticles are very similar in the four species : small, imbricate, with three points, the middle one longest. Denticles of *G. melastomus* and *G. murinus* are somewhat stronger. The denticles of *G. melastomus* show an interesting reticulation on their surface. This feature is slightly developed in the denticles of *G. atlanticus* (fig. 6). The differences in denticles of these two species as stated by VAILLANT (1888), i.e. middle ridge narrower and more salient, and lateral point less divergent in *G. atlanticus*, were not observed by the authors.

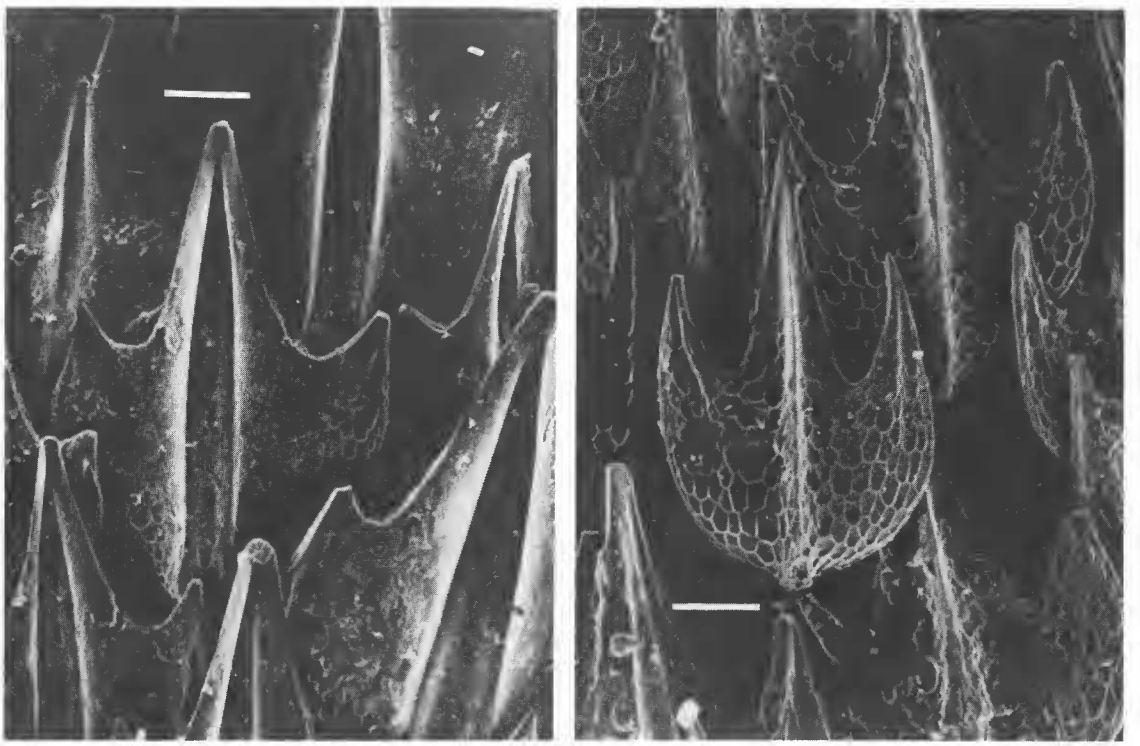

FIG. 6. — SEM photographs of denticles from right shoulder of *Galeus atlanticus* (left) and *G. melastomus* (right). White line = 0.1 mm.

Claspers

A first investigation of the external clasper morphology of the four NE-Atlantic species of *Galeus* indicates that interspecific differences exist. However, due largely to the lack of comparative studies of this character complex (except for the Rajoidei), an analysis of the

external and skeletal structure of the clasper is not yet possible. This will be the subject of a special investigation to be published later.

Reproduction

Unlike *G. polli*, which is an ovoviviparous species (CADENAT, 1959 ; CADENAT and BLACHE, 1981), *G. atlanticus* is oviparous. Nine egg capsules, ready to be laid, were observed in one female of *G. atlanticus*. The frequency of females with egg capsules in the sample studied was very high, about the 80 % of the total number of females.

The egg capsule of *G. atlanticus* is coriaceous, has no tendrils, and is very similar in shape to that of *G. melastomus*, but it is smaller, 38-40 by 11-13 mm. The usual size of egg capsules of *G. melastomus*, 600-640 mm TL from the Mediterranean, is 50-53 by 16-17 mm. An egg capsule from a female of *G. melastomus* 650 mm TL from the Rockall Trough measured 69 by 21 mm.

Sexual maturity is reached in *G. atlanticus* at a size intermediate to *G. polli* and *G. melastomus*. The smallest mature male and female of *G. atlanticus* measured 384 and 398 mm TL respectively. The larger female specimen was slightly over 450 mm TL. Specimens were considered sexually mature in the present study when males showed fully calcified claspers, and females contained egg capsules in oviducts.

The smallest mature specimen of *G. melastomus* measured 480 mm although some males of more than 500 mm did not yet have fully calcified claspers. The maximum length recorded in the literature for *G. melastomus* is 1 000 mm TL (BOUGIS, 1959, quoted by CADENAT and BLACHE, 1981, area not stated). However the largest specimens found by the present authors off Morocco measured about 730 mm.

According to CADENAT (1959), *G. polli* reaches sexual maturity between 300-350 mm TL. However, the specimen ISH 1248/64, a female 255 mm TL, contained one early embryo, attached to the yolk sac. Therefore, *G. polli* is one of the smallest species of *Galeus* at sexual maturity.

There is little data about reproduction of *G. murinus*. Male specimens studied (479-545 mm TL) had fully calcified claspers.

DISCUSSION

The identification of specimens as *G. atlanticus*, caught in the Sea of Alboran, is based on the description by VAILLANT (1888) of a female, 440 mm TL, taken near the Gibraltar Strait, 80 km west of Ceuta (Spain). The original description is incomplete, but the length of snout, tooth shape and relative size of dorsal fins are in agreement with the specimens studied here. The radiograph of the type allowed us to count 33 monospondylous and 71 precaudal vertebral centra. We conclude that the Mediterranean specimens are conspecific with the type of *G. atlanticus*, a valid species.

G. murinus is a little known species, recently considered as a subspecies of *G. melasto-*

mus (Springer, 1979). The measurements of specimens and clasper structure prove that it is a valid species, easily distinguishable from the remaining species in the Eastern Atlantic.

The actual number of species of the genus *Galeus* after the bibliography, ranges from 9 (Springer, 1979) to 11 (Nakaya, 1975, plus *G. schultzi* Springer, 1979).

A group of these species shows a tropical or subtropical distribution, and consists of small sharks, less than 420 mm TL. These species are arbitrarily grouped by distribution :

— In the E-Atlantic, *G. polli.*

— In the W-Atlantic, *G. arae* Nichols, 1927, understood as a subspecific complex by Springer (1979), including *G. arae arae, G. arae cadenati* Springer, 1966, and *G. arae antillensis* Springer, 1979 (an island form of *G. arae*). *G. cadenati* was accepted as a valid species until the review of Springer (1979), who gathered all the W-Atlantic *Galeus* in the species *G. arae*, with three subspecies. However, the status of these is still uncertain, because *G. arae*, caught off Honduras is ovoviviparous (Bullis jr. *in* Gilbert *et al.*, 1967) but egg capsules were found in *G. arae antillensis* (Springer, 1979). The different mode of reproduction would seem to be a specific character.

— In the Pacific, three species show similarities in size and distribution : *G. piperatus* Springer and Wagner, 1966 (gulf of California) ; *G. sauteri* Jordan and Richardson, 1909 (Formosa) ; *G. schultzi* Springer, 1979 (Philippines). They appear to be oviparous species (Nakaya, 1975 ; Springer 1979).

A second group of species, considered the giants of the genus, consists of *G. melastomus* and *G. nipponensis* Nakaya, 1975 (Sea of Japan). Both have the same adult sizes (600-800 mm TL), the same vertebral number (38-40 monospondylous centra) and both occur in high latitudes.

Two species cannot be included in the above groups : *G. murinus* (= *G. jenseni* Saemundsson, 1922), a moderately rare species from deep water of the northern-northeastern Atlantic, and *G. eastmani* (Jordan and Snyder, 1904), described from the Sea of Japan, with a vertebral number intermediate between *G. sauteri* and *G. nipponensis* (Nakaya, 1975).

G. boardmani (Whitley, 1928) is an enigmatic species ; it is the only *Galeus* inhabiting the temperate zone of the southern hemisphere, specifically the coast of southern Australia. The presence of a denticular crest on the lower side of the caudal peduncle and leading lower caudal fin lobe, the larger spiracle and the clasper may suggest an assignment of this species to the genus *Figaro* Whitley, 1928 (Springer, 1979). However, the denticular crest at the underside of the caudal peduncle is also present in *G. murinus.*

G. atlanticus is significantly different from *G. boardmani* and easily distinguishable from the *melastomus-nipponensis* group by its smaller size and vertebral number. *G. sauteri* and *G. murinus* have uniform colouration and shorter anal fin than *G. atlanticus.* The species of the tropical-subtropical group have a shorter anal fin base (except *G. arae cadenati* and *G. polli*), and they are smaller than *G. atlanticus* (except for *G. arae antillensis* and *G. polli*).

G. arae cadenati has a longer head and smaller eye than *G. atlanticus* (after measurements of Springer, 1966). Both dorsal fins are roughly of the same size in *G. arae cadenati*, but in *G. atlanticus* the second dorsal is larger than the first. *G. arae antillensis* has a very short anal fin base (10.9 % TL) in contrast to an average of 16.89 % TL for *G. atlanticus.*

G. polli is most similar to *G. atlanticus*, but it has a longer head, smaller and closer set dorsal fins and narrower caudal peduncle than *G. atlanticus*. Furthermore, the mode of reproduction clearly separates these two species.

The similarity between *G. atlanticus* and *G. polli* may be the reason for the misidentification in some studies. The specimens described by MAURIN and BONNET (1970) from the Mauritanian coast, identified as *G. polli*, but of larger size than the specimens described by CADENAT (1959), may totally or partially be *G. atlanticus*. SPRINGER (1979) included in his account of *G. polli* three specimens (two males, 360 and 385 mm TL, one young female, 320 mm TL) taken off Ceuta (Spain) which are probably *G. atlanticus*.

It is also possible that *G. atlanticus* has been occasionally misidentified as *G. melastomus*. RELINI and WURTZ (1975) gave a size of 380 mm for sexually mature *G. melastomus* in the Ligurian Sea (Italy). CAPAPÉ and ZAOUALI (1976) found mature specimens of 42 cm (females) and 43 cm (males). These observations, especially those of RELINI and WURTZ, may have been based, in part, on *G. atlanticus*. CERVIGON (1960) recorded the capture of numerous specimens of *Galeus* off Cape Blanc (Mauritania). He identified them as *G. melastomus*, although he pointed out that they may belong to a variety of this species. It is not possible to decide if these specimens were *G. polli* or *G. atlanticus*.

The recognition of *G. atlanticus* as a valid species will allow the biogeographical range of this species to be established in the future, and to delimit clearly the northern border of the distribution of *G. polli*.

Acknowledgments

We would like to thank the following persons for their valuable help in the completion of this paper.

Bernard SERET, Centre ORSTOM (Dakar, Sénégal), sent us two specimens of *G. polli*. Dr. M. L. BAUCHOT, Muséum national d'Histoire naturelle, Paris, provided a radiograph and data on the type of *G. atlanticus*. M[a] Dolores LINARES, Department of Paleontology, Faculty of Sciences (Málaga, Spain) made the SEM photographs of the dermal denticles. The drawing of *G. atlanticus* was made by Fernando RAMOS.

We are specially grateful to Guido DINGERKUS at the American Museum of Natural History New York, and Dr. Matthias STEHMANN at the Institut für Seefischerei Hamburg. They made an important critical revisions of the manuscript. Also Dr. STEHMMAN provided us specimens of *G. murinus, G. polli* and *G. melastomus*.

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